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Exploring the impact of self-regulation on vocabulary learning strategies and knowledge in CSL: A structural equation modeling approach

Cong Wang^{1✉}, Sida Zhu² & Yanmei Dai¹

Vocabulary learning strategies (VLSs) can significantly impact the depth and breadth of vocabulary knowledge (VK) in second language learning. However, the role of self-regulation (SR) in the relationship between VLSs and VK has not been extensively examined, particularly in the context of learning Chinese as a second language (CSL). Furthermore, the effect of varying academic efforts, especially academic achievement and academic time management, on the interplay between VLSs, SR, and VK remains largely unexplored. This study investigated 214 students enrolled in a Chinese program at a Vietnamese university to better understand these dynamics. The findings suggest that VLSs, through the mediation of SR, indirectly influenced the breadth, but not the depth, of VK. Additional research examined the impact of academic efforts on VLSs, SR, and VK. Structural equation modeling revealed that the final examination results significantly influenced the relationship between learners' SR and the breadth of their VK, whereas the midterm examination results did not have a similar impact. As for the academic time management, it was found to affect SR but did not significantly impact the overall model. This demonstrates that a well-structured study time can enhance Vietnamese university students' focus and emotional regulation, thereby improving their CSL learning.

¹The Education University of Hong Kong, Hong Kong, China. ²Guangdong University of Foreign Studies, Guangzhou, China. ✉email: wangc@eduhk.hk

Introduction

Vocabulary learning strategies (VLSs) are essential in second language (L2) learning, particularly within Chinese as a second language (CSL) learning contexts. VLSs support vocabulary learning and enhance learners' vocabulary knowledge (VK) in both breadth—the number of words known—and depth, which includes understanding of word meaning, pronunciations, grammatical forms, and appropriate contexts for use (Chiang et al. 2023; Ghalebi et al. 2020, 2021; Leontjev, et al. 2023; Li and Hafner 2022; Nation 2001; Schmitt 2014; Zhang et al. 2017). VK can be further divided into receptive knowledge (recognition and understanding of words) and productive knowledge (the ability to use words accurately in communication). This study examines both dimensions of VK, as they are key indicators of language proficiency and essential for effective communication in L2 contexts.

Despite substantial research on the effectiveness of VLSs in vocabulary learning, the complex interactions between VLSs, VK, and self-regulation (SR) remain underexplored in CSL learning contexts (Bai and Wang 2023; Dörnyei 2001; Teng et al. 2022; Tseng et al. 2006; Zhao and Ji 2018). SR, which encompasses cognitive, motivational, and behavioral aspects, enables learners to actively set learning goals and regulate their learning behaviors, ultimately leading to improved academic performance (Bai and Wang 2023; Dörnyei 2005; Teng et al. 2022; Tseng et al. 2006; Tseng and Schmitt 2008; Wang and Bai 2017).

In L2 learning contexts, particularly CSL, understanding the role of SR is crucial, as it directly influences the application of VLSs and predicts the effectiveness of vocabulary learning (Law et al. 2008; Nietfeld et al. 2014; Tseng et al. 2006; Tseng and Schmitt, 2008; Zhu and Wang 2022). SR also equips learners to manage critical elements such as time, motivation, and self-awareness, all of which are vital for academic success (Bai and Wang 2023; Broadbent and Poon 2015; Hwang et al. 2021; Panadero et al. 2017; Pintrich 2000; Theobald 2021; Zimmerman 2000). For younger L2 learners, VLSs are often employed as part of self-regulatory behaviors, particularly in time management (Choi 2016; Wolters et al. 2017). The effective time management can contribute to higher academic achievement (Archambault et al. 2022; Broadbent and Poon 2015; Crede and Phillips 2011; Hwang et al. 2021; Kitsantas et al. 2008).

Previous research has explored the relationships between VLSs and VK in L2 vocabulary learning, as well as the correlations among SR, VLSs, and VK (Bai and Wang 2023; Dörnyei 2001; Ghalebi et al. 2020, 2021; Law et al. 2008; Nation 2001; Read 1988; Schmitt 2014; Teng et al. 2022; Teng and Zhang 2022; Tseng et al. 2006; Zhao and Ji 2018). However, despite the importance of SR in vocabulary learning, few studies have thoroughly examined how VLSs indirectly influence L2 learners' VK through SR, particularly in CSL contexts. While prior research has investigated the relationship between the depth and breadth of vocabulary learning (Laufer and Goldstein 2004; Nation 2001), it has not adequately addressed the impact of other variables on these dimensions. A more in-depth investigation is required to understand the nuanced interactions between VLSs, SR, and VK, especially when additional factors that influence VK dimensions are considered. Several studies have utilized scales to measure L2 learners' VK (Calafato and Clausen 2024; Laufer and Goldstein 2004; Laufer and Paribakht 1998; Paribakht and Wesche 1993), but the role of VLSs in these findings has not been adequately explored. Similarly, while research has examined the correlation between SR, vocabulary depth and breadth separately (Bai and Wang 2023; Rød and Calafato 2023; Teng and Zhang 2022; Wang and Bai 2017), it has not thoroughly analyzed the source of these relationships or their implications for VLS use. In addition, existing studies have utilized methods such as analysis of variance

(ANOVA) to investigate factors affecting L2 vocabulary learning (Gu 2002; Nietfeld et al. 2014). However, the influence of individual academic effort, such as academic achievement and time management, on the combined effect of VLSs, SR, and VK among CSL learners remains underexplored. A deeper understanding of how these academic factors shape the interplay between VLSs, SR, and VK could yield valuable insights for improving vocabulary learning in the context of CSL.

The present study aims to develop and test a research model grounded in critical theoretical frameworks: Schmitt's (1997) model of Vocabulary Learning Strategies (VLSs) and Tseng et al.'s (2006) concept of Self-Regulating Capacity in Vocabulary Learning (SRCvoc). VLSs categorizes VLSs into six types, providing a framework to examine how learners employ strategies to acquire vocabulary. SRCvoc, on the other hand, highlights the role of self-regulation in L2 vocabulary learning. The research model guided the literature review, helping to identify core concepts, relationships between variables, and gaps in the existing literature. Drawing on prior studies that developed comprehensive questionnaires based on the VLSs and SRCvoc frameworks, this research model significantly shaped the study's questions and methodology. A quantitative approach was selected, and the questionnaire was adapted to reflect the model's structure. This ensured that the research instrument accurately measured the relevant variables. Throughout the study, the research model played a crucial role in both the discussion and conclusion phases, offering a framework for interpreting the relationships among VLSs, VK, and SR. It also highlighted potential factors, such as varying academic efforts, that might influence these relationships, offering deeper insights into the dynamics of VLSs and SR in L2 contexts.

To address identified research gaps, this study employed a quantitative research method, collecting data via a questionnaire survey, which was then analyzed using SPSS.26 and AMOS.26. Specifically, we conducted a survey to assess the usage of VLSs, the level of SR, and VK among Vietnamese university students learning Chinese. Structural equation modeling (SEM) was performed using AMOS, and Confirmatory Factor Analysis (CFA) was employed to examine the relationship among VLSs, VK, and SR. The study also investigated how varying academic achievement and time management influenced the integrated model of VLSs, SR, and VK.

This research seeks to contribute fresh insights to CSL research by addressing the following research questions:

- (1) Do VLSs significantly influence the depth and breadth of VK through SR among CSL learners?
- (2) How do academic achievement and time management affect VLSs, SR, and VK in the context of CSL learning?

Literature review

The role of vocabulary knowledge and vocabulary learning strategies in L2 learning. VK and VLSs are integral to the process of L2 learning. VK, which is crucial in understanding a learner's vocabulary proficiency, is predominately composed of two fundamental dimensions: breadth and depth. The breadth of vocabulary refers to the quantity of words a learner knows or their understanding of basic meanings, which is further subdivided into active recall, passive recall, active recognition, and passive recognition (Calafato and Clausen 2024; Chiang et al. 2023; Laufer and Goldstein 2004; Leontjev et al. 2023; Nation 2001; Stewart et al. 2024; Teng et al. 2024). These facets assess how effectively learners can retrieve and identify words, either actively or passively. In contrast, depth of VK signifies the extent of a

learner's comprehension of a specific lexical item (Calafato and Clausen 2024; Li and Hafner 2022; Nation 2001; Read 1988; Schmitt 2014; Teng and Cui 2024; Zhang 2022; Zhao and Ji 2018), which refers to the understanding of the form, meaning, and use of vocabulary. The "form" includes spoken and written forms along with word components, "meaning" entails the concept, purpose, and associations of words, while "use" covers grammatical functions, usage restrictions, and collocations (Chen and Zhang 2023; Nation 2001; Schmitt 2008; Teng et al. 2024).

To evaluate VK dimensions, researchers typically employ tools such as the "Vocabulary Knowledge Scale" and the "Computer Adaptive Test of Size and Strength." These instruments have proven useful in numerous studies designed to assess the VK of L2 learners (Laufer and Goldstein 2004; Laufer and Paribakht 1998; Paribakht and Wesche 1993; Teng and Cui 2024; Teng and Zhang 2024). While these tools are valuable for tracking vocabulary learning, they do possess certain limitations. For instance, the manual scoring process can be time-consuming and impractical when assessing large groups of learners. Moreover, although these instruments provide insights into vocabulary size and strength, they offer only a partial view of learners' overall progress in vocabulary development (Bruton 2009; Laufer and Goldstein 2004). To address these limitations, researchers have begun to utilize other tools such as the "Vocabulary Size Test" and the "Word Associates Test" (Chen and Zhang 2023; Leontjev et al. 2023; Zhu and Wang 2022). The "Vocabulary Size Test" measures the breadth of VK, giving an accurate representation of the quantity of vocabulary L2 learners possess (Nation 2012). Meanwhile, the "Word Associates Test" assesses the depth of VK, which offers insights into learners' understanding and application of the target vocabulary (Read 1998). These two tests, when used together, effectively measure the two crucial dimensions of VK (Li and Hafner 2022; Zhang 2022; Zhu and Wang 2022). Therefore, Section three in this study will implement these two tests to assess the breadth and depth of VK respectively.

VLSs represent a wide range of strategies crucial to the ongoing process of vocabulary learning. These strategies can enhance learners' L2 learning level, expand their vocabulary, encourage attempts to infer the meanings of unfamiliar words, and foster L2 vocabulary learning (Ghalebi et al. 2020, 2021; Gu 2002, 2018; Leontjev, et al. 2023; Li and Hafner 2022; Schmitt 2014; Zhang et al. 2017). To rigorously investigate these strategies and their efficacy in L2 learning, researchers commonly employ Schmitt's (1997) "Vocabulary Learning Strategies" scale.

Building upon Oxford's (1990) framework, Schmitt (1997) developed a new theoretical model by creating a scale that encompassed four out of the six categories, namely social, memory, cognitive, and metacognitive. This innovative approach was employed to examine VLSs in L2 learning, a focus that has been underscored by the majority of researchers in this field (Ma 2014). This scale has been universally acknowledged as a reliable tool that accurately reflects the array of strategies employed by L2 learners during vocabulary learning (Chen and Zhang 2023; Gu 2002, 2018; Le 2024; Schmitt 2014; Tseng and Schmitt 2008; Vu and Peters 2022; Zhang et al. 2017). Therefore, it has been selected as one of the instruments for this study. The aim is not only to gain a deeper understanding of how CSL learners use VLSs, but also to identify areas where they might need additional support or where new strategies could be introduced. This comprehensive approach ensures a thorough analysis of VLSs' application and effectiveness in L2 learning, specifically for CSL learners.

Research utilizing the "Vocabulary Learning Strategies" scale has uncovered a complex relationship between vocabulary knowledge and L2 vocabulary learning. The findings indicate that learners with a broader vocabulary are more effective in

employing activation strategies compared to those with a more limited vocabulary (Chou 2024). This suggests that L2 learners who excel in vocabulary breadth tests are more likely to use effective vocabulary learning strategies, creating a strong predictive link between their vocabulary breadth and the strategies they employ. Additionally, some studies have demonstrated that when vocabulary learning tasks are paired with assessment tools like the Vocabulary Size Test (VST), metacognitive moderation strategies—tailored to the specific tasks—significantly enhance the vocabulary learning performance of L2 learners (Teng and Zhang 2024).

A positive correlation exists between VLSs and VK. Learners with a higher level of VK tend to utilize VLSs more effectively, a trend especially evident among Vietnamese university students (Chen and Zhang 2023; Duy and Elke 2021; Hamzah et al. 2009). The more these students employ VLSs, the more proficient they become in mastering L2 vocabulary. In essence, the higher the L2 vocabulary level of Vietnamese university students, the more adept they are expected to be at implementing VLSs (Vu and Peters 2022).

Research further highlights that learners with broader VK often employ more effective VLSs, such as activation strategies, which enhance their ability to acquire new words (Calafato and Clausen 2024; Chou 2024; Teng and Zhang 2024). This suggests a reciprocal relationship, where learners with a higher level of VK are more proficient in using VLSs, and the effective use of VLSs, in turn, enhances VK. Among Vietnamese university students, this relationship is particularly significant, as those with greater VK demonstrate greater efficiency in applying VLSs (Chen and Zhang 2023; Ghalebi et al. 2020, 2021; Vu and Peters 2022).

The influence of self-regulation on vocabulary knowledge and vocabulary learning strategies.

SR is a dynamic concept that encourages learners to take an active role in their learning process (Calafato 2023; Rød and Calafato 2023; Tseng et al. 2006; Tseng and Schmitt 2008). It emphasizes the strategic efforts learners exert to manage their achievements through specific beliefs and processes (Dörnyei 2001; Tseng et al. 2006). The degree of SR can directly influence the progress of a learner's VK, with a correlation established with the use of VLSs (Tseng and Schmitt 2008). Notably, self-regulated L2 learners can enhance their VK level (both depth and breadth) by employing a variety of VLSs. For example, highly self-regulated Vietnamese university students regularly assess their L2 learning process and take appropriate actions to maintain their interest in VK (Truong and Wang 2019). They often enhance their L2 proficiency through SR learning activities such as online learning and after-class self-study, demonstrating a significant correlation between L2 ability, VK and SR (Bai and Wang 2023; Rød and Calafato 2023; Teng and Zhang 2022; Teng and Zhang 2024; Wang and Bai 2017).

In the pursuit of exploring learners' SR, researchers have developed a variety of questionnaires, such as the "Self-Regulation of Withholding Negative Emotions Questionnaire" (Kim et al. 2002), "Self-Regulated Learning" (Zimmerman 2008), "Self-Regulated Foreign Language Learning Strategy Questionnaire" (Habók and Magyar 2018), and the "English Writing Self-Regulated Learning Strategies Questionnaire" (Sun and Wang 2020). While these questionnaires have proven valuable in identifying learners' SR levels and their relationships with different variables, they have certain limitations. In particular, these tools may not accurately reflect learners' self-regulatory capacity due to their lack of a comprehensive theoretical structure. Moreover, they do not specifically analyze and test L2 learners' SR levels from the perspective of L2 vocabulary learning (Mizumoto and Takeuchi 2012; Tseng et al. 2006). Therefore, a

more specialized approach may be needed to fully understand SR in the context of L2 vocabulary learning. To further explore the use of SR in vocabulary learning among L2 learners, researchers developed the “Self-Regulating Capacity in Vocabulary Learning (SRCvoc)” scale (Tseng et al. 2006).

The structural framework proposed by SRCvoc, which is derived from Dörnyei's (2001) SR framework, has gained considerable interest among many researchers. This scale is widely recognized as a useful tool for studying the application and development of SR in L2 VK (Alamer et al. 2024; Calafato 2023; Dörnyei and Ushioda 2021; Murray et al. 2011; Rose et al. 2018; Teng and Zhang 2022). This study thereby also employs the SRCvoc scale as an instrument for Section two in the questionnaire.

While previous research has explored the relationship between VLSs and VK in the context of English as a Second Language and English as a Foreign Language, as well as research on Vietnamese university students' L2 vocabulary learning (Le 2024; Vu and Peters 2022), studies exploring the impact of SR on VLSs and VK in CSL are limited.

In recent years, SEM has been increasingly utilized by researchers to explore the intricate relationships amongst strategy, self-regulation, and motivation (Alamer et al. 2024; Calafato 2023; Murray et al. 2011; Teng and Zhang 2021; Tseng et al. 2006; Yang and Song 2024; Zhang et al. 2017; Zhang et al. 2024). Tseng et al. (2006) developed a theoretical framework based on SR, which consolidated insights from previous studies. Using this framework, they introduced an innovative tool to assess strategies used for learning L2 vocabulary and applied SEM to ascertain whether these factors' influence fell within a theoretical acceptable range. Tseng and Schmitt (2008) further expanded this framework by incorporating additional variables, specifically VK, VLSs, and the overall vocabulary learning experience. They continued the use of SEM to scrutinize the roles and interactions of these added variables within the SR framework. Later studies have introduced various variables into their respective models for path analysis. However, most still rely heavily on the theoretical foundation laid by Tseng et al. (2006), as evidenced in the research by Dörnyei and Ushioda (2021), Murray et al. (2011), and Teng and Zhang (2022). Based on this influential theoretical framework, the current study further enhances the application of SEM to meticulously investigate the relationships between VLSs, VK, and SR.

Research demonstrates that SR learners can enhance both the breadth and depth of their VK by effectively employing diverse VLSs (Truong and Wang 2019; Tseng and Schmitt 2008). Tools like the “SRCvoc” scale, which measures SR in L2 vocabulary learning, have been widely utilized in such studies (Dörnyei and Ushioda 2021; Tseng et al. 2006). For instance, studies on Vietnamese learners highlight that combining SR with online learning and self-study leads to significant improvements in VK outcomes (Bai and Wang 2023; Calafato 2023; Rød and Calafato 2023; Teng and Zhang 2022).

The influence of academic achievement and academic time management. SR, an active and multi-faceted process encompassing cognitive, motivational, and behavioral aspects, impacts L2 learners' VLSs and knowledge structure (Dörnyei 2001; Tseng et al. 2006; Zhang et al. 2024). Studies investigating the relationship between SR, academic time management, and academic achievement have found that SR correlates with better academic performance and plays a vital role in various aspects of the information processing system, particularly in the process of managing academic time (Nietfeld et al. 2014; Zhu and Wang 2022). L2 learners, influenced by SR, allocate varying amounts of

time to vocabulary learning and use of VLSs (Tseng et al. 2006). Given the time constraints of classroom-based vocabulary instruction, L2 learners need to enhance their vocabulary learning through SR and by managing their personal learning behavior (Mokhta et al. 2017; Şahin Kızıl and Savran 2018; Teng and Zhang 2022). Active use of SR increases their adaptation level to VLSs, which can stimulate their interest in L2 vocabulary learning and improve their academic performance (Shao et al. 2023; Theobald 2021). Furthermore, L2 learners with higher academic achievement, who exhibit greater SR ability and flexibility in using VLSs, tend to place significant importance on exam scores at various stages (Wilby 2020). Although the role of academic achievement and time management in L2 vocabulary learning has been explored, few studies have discussed their impact on SR, VLSs, and VK in a CSL context.

Academic achievement and time management, guided by SR, are crucial factors in L2 learners' vocabulary learning and their use of VLSs. Research indicates that learners who effectively manage their time and apply SR tend to achieve better academic results by dedicating more time to vocabulary learning outside the classroom (Nietfeld et al. 2014; Zhu and Wang 2022). This proactive use of SR not only enhances their ability to adapt to various VLSs but also increase their engagement in vocabulary learning, leading to improved academic achievement (Shao et al. 2023; Theobald 2021). Despite these findings, there is a lack of research specifically exploring the interplay between academic achievement, time management, SR, VLSs, and VK in the context of CSL learners.

Method

Participants. This study involved 214 junior students, comprising 50 males and 164 females, from a university in Vietnam. The recruitment information for participants was disseminated by a Chinese language teacher to all Chinese language majors within the university. Participation was entirely voluntary, and all students were assured that the survey would be anonymous, with results having no impact on their Chinese language studies.

The participant pool consisted exclusively of native Vietnamese speakers who had embarked on their Chinese language studies upon their enrollment at the university. Of these participants, 198 participants began their Chinese studies at university and, therefore, had three years of experience by the time of this study. Conversely, 16 participants had some prior knowledge of Chinese vocabulary due to various reasons, such as having a Chinese speaking family member, personal interest in Chinese culture, or future aspirations to study or work in China. However, they had not received any formal Chinese language education before university. In addition, 89 participants had taken the Chinese Proficiency Test (HSK), a standard Chinese language proficiency test, and 60 students had achieved Level 3 or higher. The gender imbalance in the participant sample was a reflection of the skewed gender enrollment in the university's Chinese program. While three of the participants were slightly under 18 years of age, the majority were all between 18 to 24. As a requirement, all participants had successfully completed a compulsory 30-h course titled “*Chinese Vocabulary*.” This course is designed to equip Vietnamese CSL students with a comprehensive understanding of the Chinese language. It introduces students to the pronunciation, semantics, and grammar of Chinese words, thereby enabling them to understand the meaning and usage of these words effectively.

In addition, this study extended beyond merely examining the academic achievements and time management skills of the participants. It also explored how these factors influenced their VLSs, SR, and VK. Academic achievement was gauged through

scores from both midterm and final term examinations. These served as markers of the participants' progression in their Chinese language studies. These scores not only demonstrated the learners' current comprehension and proficiency in the language but also shaped the content of future learning stages, the pedagogical strategies employed by teachers, and the students' capacity to successfully complete their language courses.

Concerning time management, the study concentrated on the amount of time participants allocated to learning Chinese on a weekly basis. A questionnaire was disseminated to the 214 participants via Google Forms, with all sections being mandatory. Out of the total, 10 participants did not complete the questionnaire within the stipulated timeframe, resulting in incomplete responses. These incomplete responses were excluded to maintain the accuracy and integrity of the dataset. Consequently, the final dataset consisted of 204 valid responses, including 50 males and 154 females.

All 204 participants were third-year university students aged 19–21, except for two students who were 22. Culturally, all participants were educated within the Vietnamese context and had no prior exposure to Chinese before university. Vietnamese was their first language, while Chinese served as their L2. Additionally, over 80% of the students identified securing a well-paying job as their primary motivation for learning Chinese.

Instrument. The questionnaire employed in this study consisted of two main parts. The first part gathered personal information about the participants, including gender, age, and the amount of weekly academic time management (T) dedicated to Chinese language learning. The second part was divided into three sections. Section one contained 52 items related to "Vocabulary Learning Strategies," designed to evaluate how effectively participants used various strategies for vocabulary learning. Section two consisted of 20 items focusing on "Self-Regulating Capacity in Vocabulary Learning (SRCvoc)," assessing the extent to which participants could self-regulate and adapt their vocabulary learning over time. Finally, section three included 100 items measuring "Vocabulary Knowledge," emphasizing both breadth and depth.

Participants were asked to respond to the items in Section one and two using a 5-point Likert scale, ranging from "1" (never) to "5" (always), based on their understanding and application of the strategies and capacities described. Section three assessed participants' Chinese vocabulary knowledge through multiple-choice questions. To ensure clarity, all items in Section one and two, as well as the depth-related items in Section three, were provided in both Chinese and Vietnamese. The Vietnamese translations were prepared by a Chinese language teacher from the participating Vietnamese university.

To ensure the research instrument accurately reflects the participants' actual levels, this study first analyzed its reliability and validity to confirm that the instrument falls within an acceptable range. Secondly, we used Exploratory Factor Analysis (EFA) to check the consistency of the questionnaire's internal factors, and then validated this with Confirmatory Factor Analysis (CFA). This ensures that the research instrument can accurately reflect the participants' VLSs and SR.

Section one. Vocabulary learning strategies. This section, based on Schmitt's (1997) "Vocabulary Learning Strategies," examined the utilization of learning strategies specific to Chinese vocabulary learning. The section consisted of 52 items, divided into two categories: discovery strategies, with 12 items (e.g., *I use a bilingual dictionary to help me translate words into my native language*), and consolidation strategies, featuring 40 items (e.g., *I*

listen to Chinese songs and news to enhance my vocabulary). The reliability and validity of this section were rigorously evaluated. High reliability was indicated by a Cronbach's α value exceeding 0.9, based on Kaiser's (1974) standards. Section one achieved a Cronbach's α values of 0.978, demonstrating excellent internal consistency. The validity of the section was also confirmed using the Kaiser–Meyer–Olkin (KMO) measure and Bartlett's test. A KMO measure greater than 0.9 and Bartlett's test result less than 0.01 indicated robust construct validity. This section achieved a KMO measure of 0.945, with Bartlett's test result confirming statistical significance ($p < 0.01$).

Section two. Self-regulating capacity in vocabulary learning. Section two focused on the self-regulatory capacity of learners during Chinese vocabulary learning. Derived from Tseng et al.'s (2006) diagnostic method SRCvoc, it aimed to identify and comprehend learners' strengths and weaknesses concerning SR in vocabulary learning. It encompassed five dimensions: commitment control (e.g., *When learning vocabulary, I have special techniques to achieve my learning goals*), metacognitive control (e.g., *I have special techniques to keep my concentration focused when learning vocabulary*), satisfaction control (e.g., *Once the novelty of learning vocabulary is gone, I easily become impatient with it*), emotion control (e.g., *When I feel stressed about vocabulary learning, I know how to reduce this stress*), and environmental control (e.g., *When learning vocabulary, I am aware that the learning environment matters*). Each dimension in Section two consisted of four items. This section also adhered to Kaiser's (1974) standards for assessing high reliability and validity. It demonstrated high reliability, with a Cronbach's α value was 0.965, indicating excellent internal consistency. The validity of the section was supported by a KMO measure of 0.946, suggesting the data was highly suitable for factor analysis. Additionally, the Bartlett's test confirmed statistical significance with $p < 0.01$, further establishing the robustness of the construct validity.

Section three. Vocabulary knowledge (breadth and depth). Section three was designed to investigate the understanding of Chinese vocabulary, including its meaning, collocation, and usage. The assessment was divided into two parts: breadth, which involved identification of Chinese vocabulary, and depth, which involved the usage of Chinese vocabulary such as synonyms and antonyms. For the breadth component, a "Vocabulary Size Test" was used as a reference (Nation 2012; Nguyen and Nation 2011). The depth component was based on the "Word Associates Test" (Read 1993, 1998). All Chinese words used in Section three were taken from the "Frequency-based HSK Vocabulary" (Yang 2016), a book that categorizes Chinese vocabulary into groups based on their frequency of use in the Chinese Proficiency Test (HSK) levels I–VI. To ensure the test was appropriate for the participants' Chinese competency level, 50 super-high frequency words were selected with the help of a teacher and a Chinese linguist. These words were used to construct items testing both breadth and depth of VK.

The breadth section comprised 50 items, each worth two points for a correct answer. Participants were required to select the correct Vietnamese translation for each Chinese word, totaling a maximum score of 100 points. For example, in an item testing the word "下午", participants had to choose the correct Vietnamese translation from four options, which should be (C).

Excerpt 1

下午: 你姐姐下午什么时候到?

- (a) ròi, rớt
- (b) trời mưa
- (c) buổi chiều
- (d) mùa hạ

The depth section used the same 50 words, with two multiple-choice items created for each word. The first item required participants to select the synonym or antonym of the given word, and the second item required them to select a word that can form a phrase or sentence with the given word. Each correct answer was worth one point, with a maximum score of 100 points. For instance, in an item testing (Except 2) the word “老師”, participants first had to choose the synonym or antonym of the word from four options. “(a) 學生 *sinh viên*” is the correct answer because the words “(a) 學生 *sinh viên*” is the antonym of “老師 *giáo viên*”. They then had to select a word that could form a phrase or sentence with “老師”. “(a) 漢語 *Hán ngữ*” is the correct answer because it is the only word that can construct a phrase/sentence with the given word “老師 *giáo viên*” to form “漢語老師”.

Excerpt 2

- (1) 老師 *giáo viên*
 - (a) 學生 *sinh viên*
 - (b) 媽媽 *mẹ*
 - (c) 旅遊 *du lịch*
 - (d) 跑步 *chạy bộ*
- (2) 老師 *giáo viên*
 - (a) 漢語 *Hán ngữ*
 - (b) 西瓜 *dưa hấu*
 - (c) 好吃 *ngon*
 - (d) 後來 *sau này*

By using this comprehensive approach, Section three aimed to provide a thorough assessment of participants' understanding and usage of Chinese vocabulary. The reliability of this section was deemed acceptable, with Cronbach's α scores of 0.791 for vocabulary breadth and 0.877 for vocabulary depth. These results align with the reliability standards established by Alderson et al. (1995), confirming that the assessment tools were consistent and suitable for evaluating participants' VK.

Procedure. The data collection process for this study was executed through Google Forms from June 6 to June 16, 2021. This method was selected for two main reasons. Firstly, Google Forms provides a streamlined and efficient way to gather data. Secondly, it enables accurate tracking of each participant's serial number, the time spent filling out the questionnaire, and detects any missing data. This ensures that the data recorded is thorough and properly accounted for, bolstering the accuracy of our study.

The process began with a pilot study conducted from June 6 to June 8, 2021, involving 34 students: 9 males and 25 females. All the participants held an HSK level 3 or higher certificate and had more than three years of experience in learning the Chinese language. The pilot study was administered in a controlled environment, where participants individually filled out the questionnaire using their personal devices like cell phones, tablets, or laptops. To maintain the integrity of the study, participants were not allowed to communicate with each other or access the internet for information. A teacher was present to oversee the process and monitor the time taken to complete the questionnaire.

After the pilot study, the participants were encouraged to provide feedback. They indicated that the timeframe was insufficient, and some parts of the questionnaire were unclear. Based on this feedback and consultation with the supervising teacher, the questionnaire was revised for clarity, and the time limit was extended to 35 min. To ensure that the modified questionnaire could more accurately measure the participants'

performance on the variables, reliability and validity tests were conducted using SPSS.26, confirming the questionnaire's high level of acceptability. Additionally, an EFA was conducted using SPSS.26, and a CFA was performed using AMOS.26 to verify the internal consistency of the questionnaire. The updated questionnaire was then distributed to all participants via Google Forms on June 9, 2021, with a submission deadline of June 16, 2021. Any responses received after this deadline were excluded from the study. Additionally, questionnaires that exceeded a 35-min completion time or had missing information were deemed invalid, resulting in the exclusion of ten students due to late submissions.

The collected data were analyzed using SPSS.26 and AMOS.26 for EFA and CFA respectively. The purpose of these analyses was to investigate the influence of SR on the relationship between VLSs and VK. A SEM was constructed using the data collected, based on the theoretical frameworks of VLSs and SR. Further, the moderating effects of academic time management and achievement on the model were examined using AMOS.26.

The dataset for this study comprised 204 valid cases, with the model anticipating five latent variables and no expected bidirectional interaction between them. According to the literature, the sample size requirements for SEM suggest that a higher scale reliability results in a lower sample size requirement, especially when the distribution of variables is normal and the number of observed indicators per latent variable is three or more (Kline 2015). It is generally agreed that a minimum of 100 cases is required for maximum likelihood estimation, but a sample size of 200 is more robust and suitable for SEM (Loehlin 1992). Considering these factors, this study meets the essential requirements for the development of SEM and the subsequent implementation of maximum likelihood estimation, thereby facilitating a deeper understanding of the relationships among the variables.

Results

The impact of self-regulation on the connection between vocabulary learning strategies and vocabulary knowledge

Extraction of factors from EFA and verification through CFA. An EFA was employed to scrutinize VLSs and SR. Items with a factor loading below 0.6 were excluded, and the rest were grouped and renamed for further analysis. As per Schmitt (2014), three factors were identified: Memory Strategies (MS, items 1, 23, 33, 34, 38), Deterministic Strategies (DS, items 4, 5, 6), and Metacognitive Strategies (MES, items 43, 44, 45, 48, 50). MS pertains to how the learner memorizes and recalls new information (e.g., *I will summarize the characteristics of different words when learning Chinese vocabulary*). DS are strategies where learners decipher the meaning of new vocabulary (e.g., *I can think of Chinese words according to the context*). MES are learners' methodologies to achieve language learning (e.g., *I write notes in a Chinese vocabulary course*).

Within SR, two factors were identified: Emotion Control (EC, items 4, 6, 19) and Metacognitive Control (MEC, items 11, 12, 14, 16), named following Tseng et al. (2006). EC relates to the learner's ability to manage negative states and promote positive emotions (e.g., *I am satisfied with the methods I use to reduce the stress of learning Chinese vocabulary*). MEC involves the learner's ability to monitor and control their attention to ensure efficient learning (e.g., *I am aware of the importance of the learning environment when learning Chinese vocabulary*).

To authenticate the classification results from EFA and to ensure the accuracy of factor classification, CFA was conducted on the extracted factors using AMOS.26. According to the theoretical framework of this study, the relationship between

variables and the error terms was initially determined to establish the SEM. SEM was evaluated by the following indicators: χ^2/df , the Comparative Fit Index (CFI), the Goodness of Fit Index (GFI), the Adjusted Goodness of Fit Index (AGFI), the Normed-fit Index (NFI), and the Root Mean Square Error of Approximation (RMSEA). In this case, referring to the previous criterion (Byrne and Stewart 2006), χ^2/df needs to be less than 2, acceptable values of CFI, GFI, AGFI, and NFI are 0.90 and above, and the RMSEA value of 0.08 or less is usually considered as an acceptable and reasonable range. By adjusting the model, it was found that $\chi^2/df = 1.748$, CFI = 0.945, GFI = 0.934, AGFI = 0.058, NFI = 0.91, RMSEA = 0.061, and the results indicate that the model fit indices were within acceptable levels, confirming that the factor classification was logical and satisfied the requirements of the SEM.

Mediating effect of self-regulation. A SEM was developed using AMOS.26 to explore the potential mediating role of SR in the relationship between VLSs and VK. The model posited VLSs as the independent variable, VK as the dependent variable, and SR as the mediating variable. AMOS.26 was utilized to test whether the VLSs, the independent variable, indirectly impacted the dependent variable of VK through the mediator variable of SR and whether there was a significant predictive relationship between these factors.

To enhance the accuracy and reliability of the model, several measures were implemented. Initially, the placement of variables within the model was verified to ensure that VLSs indirectly impacted VK, mediated by SR. Following that, based on the modification indices (M.I.) - a method previously employed in studies by Do-Thi and Do (2022) and Zhang et al. (2017) - necessary adjustments to the model were carried out using the results obtained from the AMOS output. These steps were taken to logically structure the model and increase its precision.

This involved locating the covariances where the maximum M.I. value occurred and applying double arrows for correction. If the two items with the maximum covariances were not on the same level, i.e., one was a latent variable and one was an observed variable, the observed variable was removed. These steps were repeated until the model indices were within an acceptable range (Do-Thi and Do 2022). The model's indicators suggested acceptable model fit, with CMIN/DF = 1.748, CFI = 0.945, RMSEA = 0.061, and TLI = 0.934. In terms of regression weights, the regression coefficients of MES and MS were significantly related to vocabulary breadth ($p = 0.02$ and 0.009 , respectively). The correlation coefficients (covariances) also achieved significant levels ($p < 0.05$). However, the regression coefficient of VK (depth) did not reach a significant level ($p > 0.05$), indicating that the depth of VK may not be strongly influenced by the same variables (see Fig. 1).

An analysis of the impact of DS on vocabulary breadth reveals that the indirect effect of DS (0.043) surpasses its direct effect. This finding suggests that DS exerts a stronger influence on the breadth of VK through the mediating role of SR (see Fig. 1 and Table 1). The presence of both direct and indirect effects indicates that Vietnamese university students can effectively expand their Chinese vocabulary through the strategic application of VLSs. The prominent indirect effect highlights SR as a crucial role in amplifying the effectiveness of DS, thereby significantly contributing to vocabulary enhancement. This may be because SR enables students to sustain a high level of interest in vocabulary learning, supported by guidance from teachers and collaboration with peers, which facilitates a deeper understanding of Chinese vocabulary items.

On the other hand, the MES demonstrated an indirect effect of 0.057 but had a direct effect of -0.344 . Despite the existence of

both direct and indirect effects, the overall influence of MES on vocabulary breadth was negative. This negative correlation suggests that increased use of MES might actually lead to a reduction in vocabulary breadth. This could be because Vietnamese university students acquire much of their Chinese vocabulary from daily life activities—such as interacting with classmates and teachers, watching Chinese videos, and listening to Chinese music—rather than through formal learning strategies. If these life-based learning opportunities are reduced, their understanding of Chinese vocabulary could decline significantly. Additionally, MS was found to indirectly affect vocabulary breadth through SR, with an indirect effect of -0.048 . This indicates that MS may indirectly diminish vocabulary breadth by negatively influencing SR. Although memory strategies contribute to vocabulary learning by aiding in the memorization and comprehension of Chinese words, their impact on SR, such as setting learning goals and regulating behaviors, could lead to a decrease in Chinese vocabulary. This might be because systematic vocabulary learning, which requires extensive memorization, could reduce students' interest in learning Chinese, ultimately leading to a decline in vocabulary learning.

Overall, while all three vocabulary learning strategies (DS, MES, and MS) were found to affect vocabulary breadth through SR, the magnitude of their indirect effects varied. This highlights the complex role those different strategies play in shaping vocabulary breadth via SR. The findings suggest that SR is a significant factor in Chinese vocabulary learning for Vietnamese university students, with its influence potentially being either positive or negative depending on their learning habits and environment. Notably, while SR impacts vocabulary breadth, it does not significantly affect vocabulary depth, indicating that vocabulary depth is relatively stable and less influenced by SR.

While all three components of VLSs (DS, MES, and MS) were found to affect vocabulary breadth through SR, the magnitude of their indirect effects varied. This points to the nuanced role of different VLSs in shaping vocabulary breadth through the mediating factor of SR. Overall, the role of SR in Chinese vocabulary learning should be noticed. Vietnamese university students can be influenced by setting learning goals and regulating learning behaviors. It is important to note that this influence may be positive or negative in terms of breadth due to the Chinese learning habits and atmosphere of Vietnamese university students. In addition, the depth involves vocabulary usage, and the effect of SR fails to cause any significant change in it, suggesting that the depth of vocabulary is relatively stable compared to the breadth and will not be significantly changed by the effect of SR.

The influence of academic time management and achievement

The role of academic achievement in the model. The participants' academic achievement was gauged based on their scores in the midterm and final examinations of the Chinese vocabulary course. Participants were then categorized into three different groups for a multigroup analysis: the “normal group” represented average achievers, the “good group” for those who scored above average, and the “excellent group” for those with top scores.

Initially, an ANOVA test was conducted using SPSS.26 to identify differences between these three groups in terms of VLSs, VK, and SR. The results, as shown in Table 2, revealed a significant difference among all three groups for VLSs, VK, and SR, with a p-value of less than 0.05 and individual significance of less than 0.01. This significance indicated that AMOS.26 could be utilized for a multi-group analysis. The model's fit indices results indicated similar trends for both the midterm and final examination scores (see Table 3).

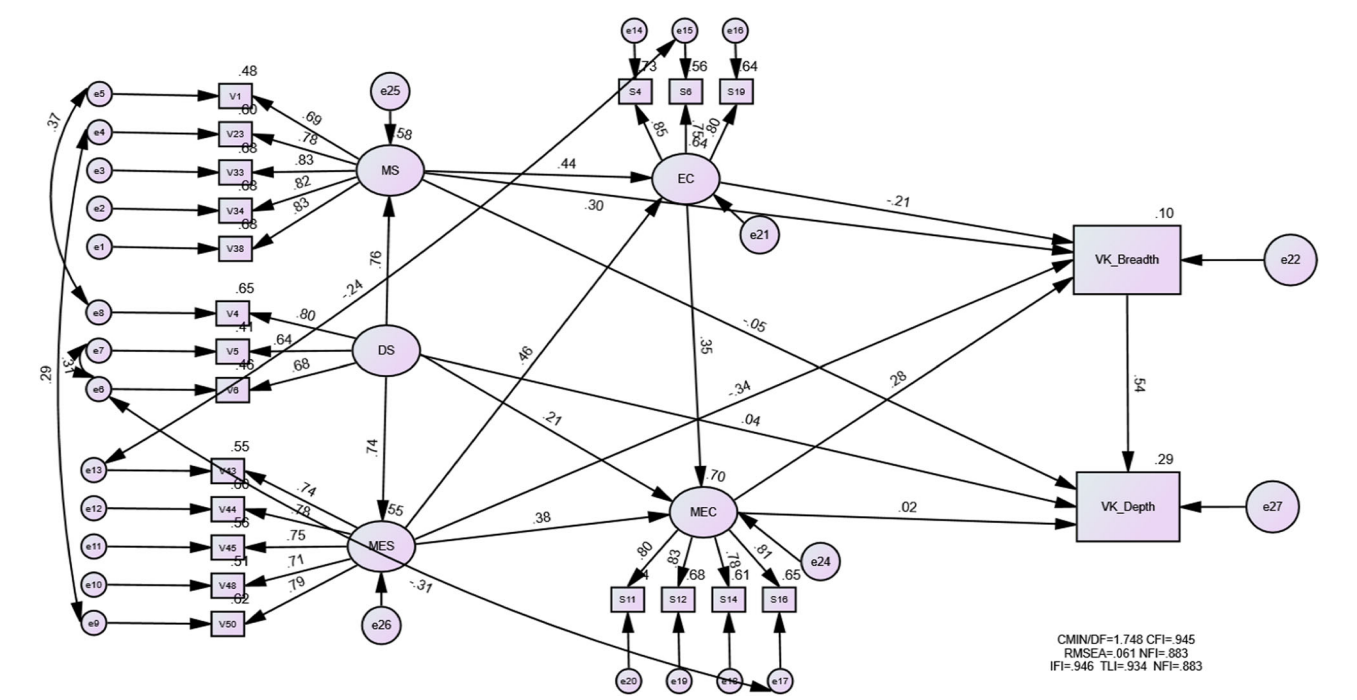


Fig. 1 The mediating effect of SR. EC emotion control, MEC metacognitive control, MS memory strategies, DS deterministic strategies, MES metacognitive strategies, VK_Breadth breadth of vocabulary knowledge, VK_Depth depth of vocabulary knowledge.

Table 1 Summary of the total, direct and indirect effects.			
Items	Direct effects	Indirect effects	Total effects
DS on VK_Breadth/VK_Depth	0.00/0.043	0.043/−0.004	0.043/038
MES on VK_Breadth/VK_Depth	−0.344/0.00	0.057/−0.145	−0.286/−0.145
MS on VK_Breadth/VK_Depth	0.305/−0.504	−0.048/0.142	0.256/−0.362

MS memory strategies, DS deterministic strategies, MES metacognitive strategies, VK_Breadth breadth of vocabulary knowledge, VK_Depth depth of vocabulary knowledge.

Table 2 The results of ANOVA (midterm and final examination).					
		VLSs	SR	VK-Breadth	VK-Depth
Depth	Midterm examination	normal group(sig.)	0.036	0.013	0.045
		good group(sig.)	0.032	0.001	0.030
		excellent group(sig.)	0.026	0.039	0.008
Final examination		normal group(sig.)	0.023	0.029	0.016
		good group(sig.)	0.002	0.004	0.023
		excellent group(sig.)	0.000	0.001	0.049

In the analysis of the five models, none yielded significant results ($p > 0.05$), with most indicators showing low values. Furthermore, the chi-square test did not reveal any significant differences across the models in relation to their respective degrees of freedom. This outcome affirmed that the midterm examination, as a moderating variable, did not have an impact on the model.

However, the final examination demonstrated acceptable indicators for each group. Significant variances were identified between M_2 and M_1 , M_4 and M_3 , and M_5 and M_4 ($p < 0.05$). As a result, pairwise parameter comparisons were necessitated to further scrutinize these differences (see Table 4).

According to the data presented in Table 4, a comparison was made between Group 1 (normal) and Group 3 (excellent) within

the unconstrained model. The comparison focused on two pathways, namely 1) $a7_1$ and $a7_3$, and 2) $a8_1$ and $a8_3$, as depicted in Figs. 2 and 3, which represented the MES. Numerically, $a7_1 > a7_3$ and $a8_1 > a8_3$, demonstrating that the normal group outperformed the excellent group in terms of MES. Additionally, pathways 1) $a17_1$ and $a17_3$, and 2) $a19_1$ and $a19_3$ were also analyzed. These pathways represented the EC to the breadth of VK, and MEC to the breadth of VK, respectively.

In terms of numerical values, the excellent group outperformed the normal group. However, when considering the structural weight, the good group held a higher value within the model than the excellent group ($c5_2 > c5_3$), suggesting a stronger contribution to the model. In relation to structural covariances, the

Table 3 Multiple-group analysis (academic achievement).

	Model	χ^2	df	χ^2/df	GFI	CFI	TLI	IFI	NFI	RMSEA	$\Delta\chi^2(\Delta df)$
ME	1	355.62	191	1.862	0.754	0.856	0.826	0.861	0.742	0.099	
	2	396.82	191	2.078	0.614	0.752	0.7	0.763	0.626	0.156	
	3	364.06	191	1.906	0.734	0.803	0.762	0.812	0.672	0.115	
	M ₁	1147.66	573	2.003	0.648	0.802	0.761	0.81	0.681	0.074	
	M ₂	1196.40	617	1.939	0.673	0.848	0.776	0.806	0.668	0.071	48.737(44)
FE	M ₃	1214.53	633	1.913	0.669	0.801	0.781	0.804	0.663	0.071	18.126(16)
	M ₄	1214.54	635	1.919	0.669	0.8	0.782	0.805	0.663	0.07	0.013(2)
	M ₅	1253.05	643	1.949	0.661	0.801	0.774	0.794	0.652	0.072	38.513(8)
	1	341.62	191	1.789	0.748	0.864	0.835	0.869	0.745	0.067	
	2	382.44	191	2.002	0.628	0.817	0.779	0.824	0.7	0.053	
	3	319.21	191	1.671	0.77	0.847	0.815	0.854	0.702	0.062	
	M ₁	1044.94	573	1.824	0.726	0.842	0.809	0.849	0.717	0.061	
	M ₂	1133.75	617	1.838	0.707	0.827	0.806	0.832	0.693	0.082	88.81(44)
	M ₃	1153.58	633	1.822	0.704	0.826	0.81	0.83	0.687	0.088	19.837(16)
	M ₄	1161.80	635	1.83	0.703	0.824	0.808	0.827	0.685	0.143	8.219(2)
	M ₅	1192.85	643	1.855	0.699	0.816	0.802	0.819	0.677	0.137	31.051(8)

ME midterm examination, FE final examination, "1" = normal group, "2" = good group, "3" = excellent group.

Table 4 Critical ratios for differences between parameters.

Model	Path	CR	Point
Unconstrained	a7_1 vs. a7_3	-2.342	0.77 vs. 0.5
	a8_1 vs. a8_3	-2.702	0.8 vs. 0.69
	a14_1 vs. a14_3	2.125	0.76 vs. 0.87
	a17_1 vs. a17_3	-2.475	0.12 vs. 0.6
	a19_1 vs. a19_3	2.215	0.01 vs. 0.93
Structural weights	c5_2 vs. c5_3	-2.234	-0.24 vs. -0.47
Structural covariances	vv1_1 vs. vv1_2	-3.42	0.03 vs. 0.29
	vv2_1 vs. vv2_2	-3.615	0.25 vs. 0.03
	vv2_1 vs. vv2_3	-2.472	0.25 vs. 0.09

good group showed superior performance compared to the normal group in the aspect of EC. When considering MEC, the normal group recorded the highest value, followed by the good group, and then the excellent group. This indicates that, in terms of MEC, the normal group had the most significant influence.

The impact of academic time management on the model. The parameter of academic time management, represented as T (hours), was divided into three groups for multigroup analysis: $0 < T < 5$, $5 \leq T < 15$, and $T \geq 15$.

An ANOVA test was conducted using SPSS.26 to examine the differences among the three groups in terms of VLs, SR, and VK. The results are displayed in Table 5. According to the SPSS.26 analysis, all the groups exhibited a p-value of less than 0.05, which reached the level of significance, except for one group which showed a p-value greater than 0.05. This indicates that despite one group's exception, there is a significant difference among the groups in terms of VLs, SR, and VK. Therefore, it is appropriate to use AMOS.26 for a multigroup analysis.

The indices across all groups were found to be similar, with marginal gaps between them, suggesting that the model was both reasonable and stable. Following this, the SEM was further divided into five models. A significant difference was found between models M₅ and M₄ ($\Delta\chi^2 = 25.927$, $\Delta df = 8$, $p = 0.01 < 0.05$), which indicated that at least one of the pathways among the various groups, namely vv1_1, vv2_1, vv3_1, vv4_1 in the " $0 < T < 5$ " group; vv2_1, vv2_2, vv3_2, vv4_2 in the " $5 \leq T < 15$ " group; vv3_1, vv3_2 in the " $T \geq 15$ " group; and vv3_3 and vv4_3, is significant (see Fig. 4). To identify the

significant path, the CR value was further examined. Only four groups had a CR value greater than 1.96 (vv1_1 & vv1_3 = -2.585, vv2_1 & vv2_2 = 2.144, vv1_2 & vv1_3 = -3.468, vv2_2 & vv2_3 = -2.929), which accounts for less than half of all groups. The CR values of the remaining paths were below 1.96, indicating they were not significant. These results revealed that academic time management does not moderate the relationship between VLs and VK.

Furthermore, vv1_1, vv1_2, and vv1_3 represented the residuals of EC. Upon combining the model, the values were observed as vv1_1 = 0.28, vv1_2 = 0.29, and vv1_3 = 0.04, arranged in ascending order. Similarly, for MEC, the values of vv2_1 and vv2_2 were observed as 0.09 and 0.22, respectively. Upon comparison, the CR values were found as follows: vv1_1 and vv1_3 yielded a CR value of -2.585, vv2_1 and vv2_2 resulted in a CR value of 2.144, vv1_2 and vv1_3 produced a CR value of -3.468, and vv2_2 and vv2_3 had a CR value of -2.929. While the absolute value of CR in these four groups was greater than 1.96, it did not account for more than half of the total groups. Such a result suggests that SR in vocabulary learning was affected by time management, but this result did not affect the model as a whole. In other words, the conclusion was drawn that academic time management did not exhibit moderating effects within this context.

Discussion

The impact of self-regulation on vocabulary learning strategies and vocabulary knowledge. The model results indicate that SR plays a crucial mediating role in vocabulary learning, aligning with previous studies (Calafato 2023; Nietfeld et al. 2014; Rød and Calafato 2023; Truong and Wang 2019; Wang and Bai 2017). Furthermore, these findings support the theoretical framework of SRCvoc proposed by Tseng et al. (2006), highlighting its importance in vocabulary learning, particularly for Vietnamese university students learning Chinese. This suggests that SR is essential for these students to effectively expand their Chinese vocabulary. However, it is important to note that SR did not have a significant impact on vocabulary depth. This limitation indicates that while SRCvoc is valuable, it may need to be further refined and adapted to better suit the needs of Vietnamese learners of CSL. The study also examined the Vocabulary Learning Strategies theory proposed by Schmitt (1997) and found that it significantly influences vocabulary learning. Unlike previous studies, this research revealed that the impact of different

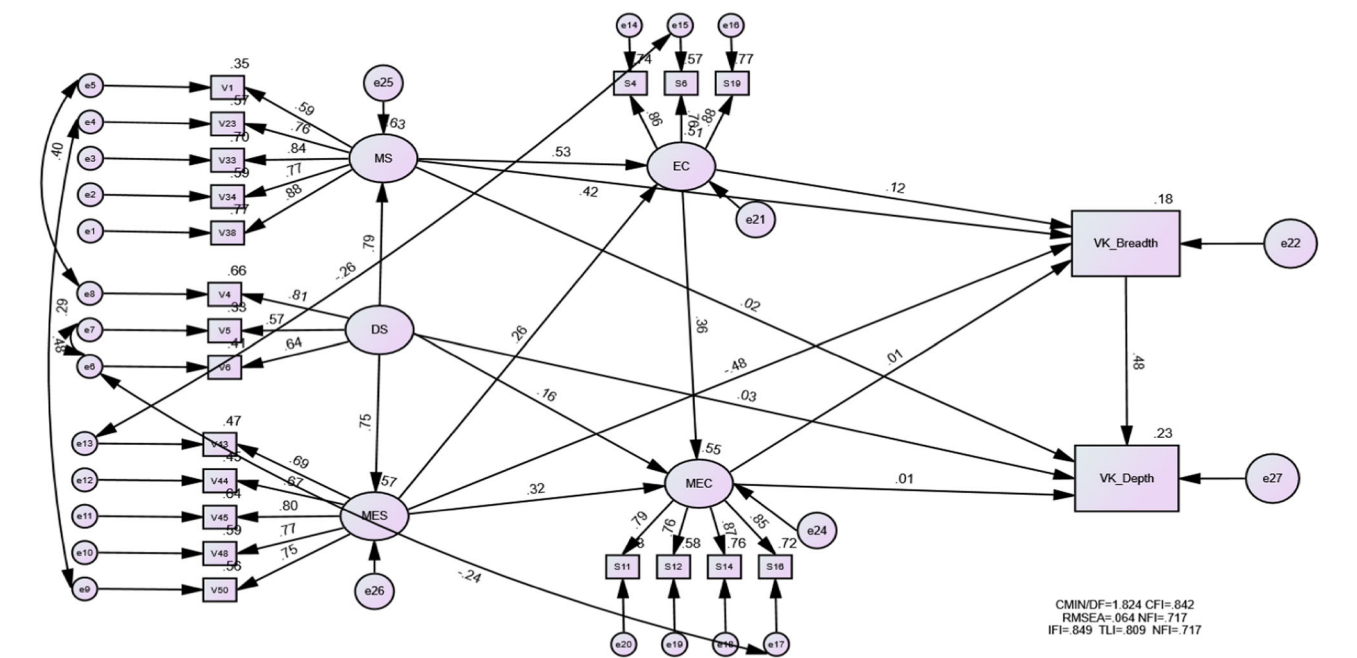


Fig. 2 Unconstrained model (normal group). EC emotion control, MEC metacognitive control, MS memory strategies, DS deterministic strategies, MES metacognitive strategies, VK_Breadth breadth of vocabulary knowledge, VK_Depth depth of vocabulary knowledge.

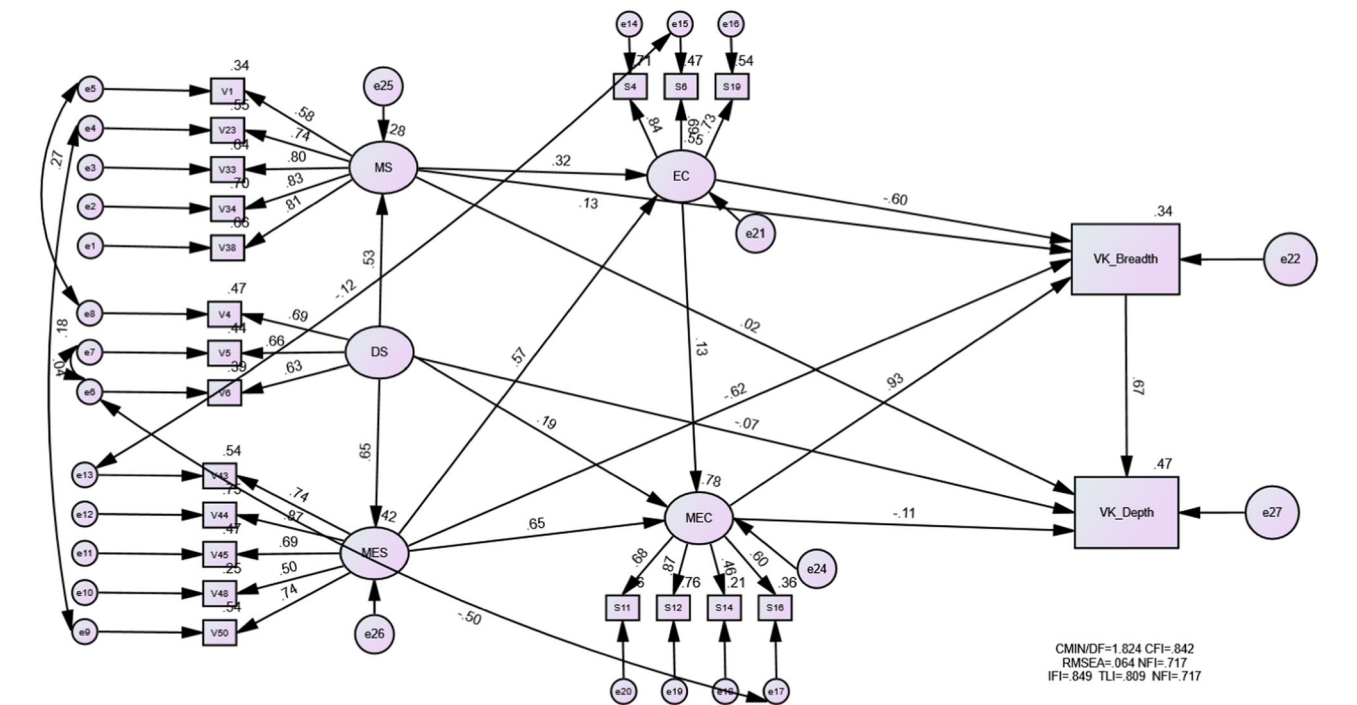


Fig. 3 Unconstrained model (excellent group). EC emotion control, MEC metacognitive control, MS memory strategies, DS deterministic strategies, MES metacognitive strategies, VK_Breadth breadth of vocabulary knowledge, VK_Depth depth of vocabulary knowledge.

Table 5 The results of ANOVA (academic time management).					
		VLSs	SR	VK-Breadth	VK-Depth
Academic time management	0 < T < 5 (sig.)	0.001	0.009	0.000	0.291
	5 ≤ T < 15 (sig.)	0.000	0.004	0.000	0.008
	T ≥ 15 (sig.)	0.000	0.004	0.000	0.008

T = hours.

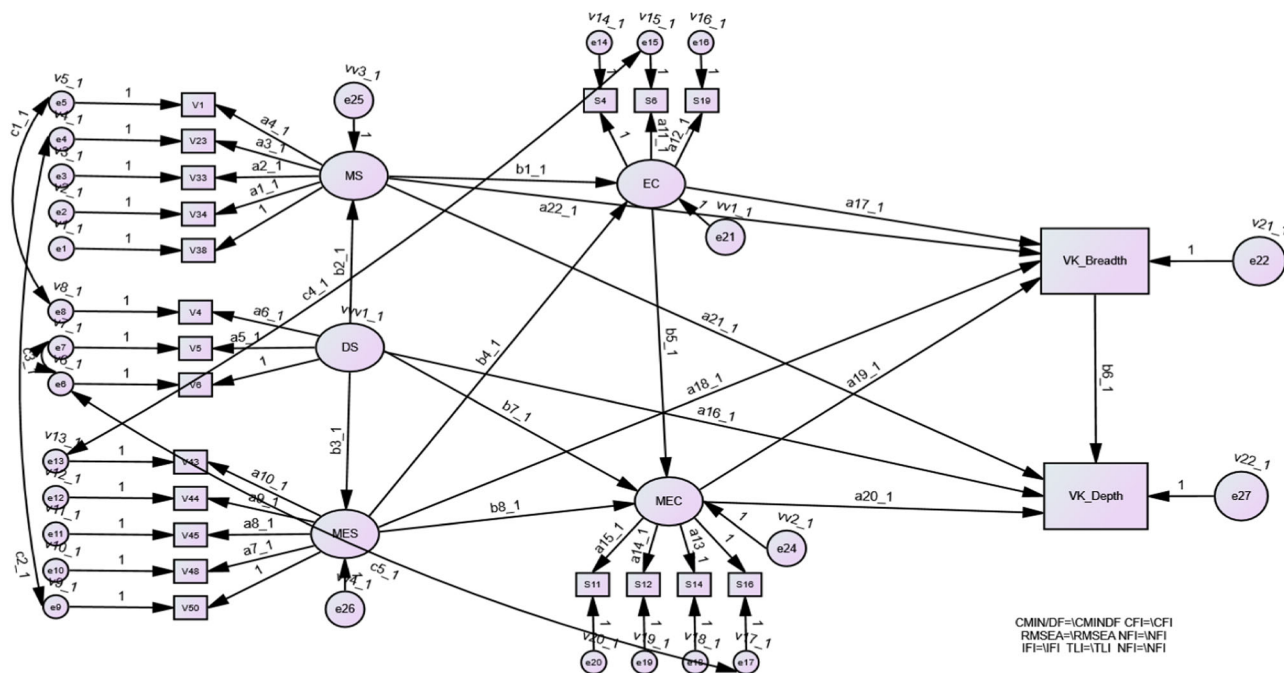


Fig. 4 Academic time management. EC emotion control, MEC metacognitive control, MS memory strategies, DS deterministic strategies, MES metacognitive strategies, VK_Breadth breadth of vocabulary knowledge, VK_Depth depth of vocabulary knowledge.

vocabulary strategies on vocabulary breadth varies significantly depending on the role of SR. This finding underscores that the effectiveness of vocabulary learning strategies is not static; rather, it can fluctuate based on various factors, including the learner's ability to self-regulate.

As learners' ability to manage negative emotions and maintain focus on vocabulary learning improves, their use of DS and MES also enhance, leading to an increase in their breadth of Chinese VK. This finding aligns with previous studies, which show a significant correlation between VLSs and SR (Roth et al. 2016). Additionally, while MES were found to predict vocabulary breadth, they did not directly influence depth. The results also confirm existing research that SR influences learners' VK (Le 2024). However, this effect was observed primarily in vocabulary breadth, consistent with previous findings (Zhu and Wang 2022). This suggests that while VLSs can affect vocabulary depth, which reflects learners' mastery of vocabulary forms and usage, such changes are relatively stable. Vocabulary depth appears less susceptible to fluctuations caused by internal factors, such as learners' emotions, or external stimuli that might otherwise prompt changes in vocabulary comprehension and utilization. Although this finding contrasts with some earlier studies (Calafato 2023; Truong and Wang 2019; Wang and Bai 2017), it highlights the nuanced relationship between the two dimensions of VK—breadth and depth—under the influence of SR and VLSs. These results suggest that VLSs can effectively elevate students' overall vocabulary levels and deepen their understanding of Chinese vocabulary. Moreover, the model demonstrates that SR indirectly predicts the relationship between VLSs and students' vocabulary breadth, emphasizing the role of SR in facilitating vocabulary learning. While prior studies have highlighted the importance of MS, which involves personal knowledge and information storage, as a key factor in enhancing vocabulary learning (Nation and Gu 2019), this study's model reveals a more nuanced finding. Specifically, MS indirectly affects vocabulary breadth through SR, but with a negative path coefficient. This suggests that while VLSs can indirectly predict vocabulary breadth through SR, the impact of MS may not always be

positive. Vietnamese university students could potentially improve their vocabulary breadth by actively employing MES within VLSs, but this improvement is indirectly shaped by the influence of teachers and peers. The results may reflect external pressures, such as the influence of teachers and peers, as well as the motivation driven by job-seeking pressure (Le 2024). These factors likely encourage Vietnamese university students to engage more actively in Chinese vocabulary learning, resulting in more motivated learning behaviors, increased engagement, and better learning outcomes. However, the study found that vocabulary depth was not significantly affected. One possible explanation is that the difficulty of Chinese vocabulary, particularly in terms of form, meaning, and usage, diminishes the enjoyment of learning, leading to less motivation to delve deeper into vocabulary study.

Students mainly accumulate Chinese vocabulary through appropriate personal VK storage, deep understanding of the meanings of new words, and memory reinforcement of the meanings of old words, all of which show an increasing trend under the influence of personal attention and positive emotions. It is important to note, however, that an excessive VK reserve might lead to memory and understanding deficits, posing challenges in differentiating words. By regulating their emotions and focus, students can timely enhance their VLSs performance, which aids them in understanding the meanings of vocabulary and in expanding their vocabulary breadth. To support this process, Chinese language teachers at Vietnamese universities could use language learning apps to introduce contemporary Chinese vocabulary and explain its meanings and usage through engaging video and audio materials. This approach can help students memorize vocabulary more efficiently. Additionally, teachers could provide authentic Chinese learning environments, such as facilitating interactions between Vietnamese and Chinese students, organizing visits to Chinese enterprises, and helping students understand the use of Chinese vocabulary in various conversational contexts. These strategies can enhance students' interest in learning Chinese while simultaneously improving their vocabulary skills.

Finally, educators could incorporate theoretical frameworks such as VLSs (Schmitt 1997) and SRCvoc (Tseng et al. 2006) in their teaching. The VLSs framework can guide students in improving their understanding of vocabulary using mnemonic and metacognitive strategies, while the SRCvoc framework can help teachers instruct students on identifying and correcting errors in their vocabulary learning process.

The moderating effects of academic time management and academic achievement on vocabulary learning

Two different impacts of academic achievement on vocabulary learning. Academic achievement, represented by midterm and final examination results, is a measure of an individual's language proficiency, which significantly influences SR and learning strategies (Zimmerman 1990). This study confirmed that final examination results significantly moderate the relationship between VLS, SR, and VK, namely the VLS-SR-VK model. To achieve high scores in final examinations, students employ a variety of VK strategies for self-regulated learning, therefore improving their VK. The application of VLSs, such as memorizing and understanding new words and reinforcing and deepening knowledge of old words, varied significantly among students, and influenced individual vocabulary learning based on individual emotion and SR. However, midterm scores did not have the same moderating effect. This corroborates findings that midterm grades, reflecting a shorter learning period, cannot represent a learner's overall academic achievement (Treffers-Daller and Milton 2013). This could be due to the fact that at the university where the study was conducted, midterm examination scores do not affect students' final course scores, leading to less effort and importance attributed to midterms.

SR strategies can help normal and good students improve exam scores because they can aid students in focusing on essential content and understanding key points likely to be examined. However, for excellent students, SR may not necessarily lead to further improvement in academic performance. This is because they can meet school requirements effortlessly and may use SR to expand their knowledge outside of exam content, which may not contribute to higher exam scores. As a result, even with high levels of SR, their exam scores may not necessarily increase. Further, excellent students may rely less on EC and VLSs than their lower-scoring counterparts. These students often employ a broader range of learning strategies, such as seeking help from teachers, classmates, and parents to address potential challenges in vocabulary learning (Zimmerman 1990). This diversified approach to learning may not directly contribute to higher exam scores, but it allows them to engage more deeply with the material and develop a more comprehensive understanding.

The non-significant effect of academic time management on vocabulary learning. While academic time management is often considered crucial for second language learning effectiveness (Vohs and Schmeichel 2003), this study found that it did not significantly influence the relationship between VLS, SR, and VK. This implies that variations in academic time management do not significantly affect the breadth and depth of VK. Variation in other related factors (EC and MES) might be employed for the explanation.

As the weekly academic time commitment to Chinese learning increases, there is a corresponding improvement in the level of EC. However, this trend begins to decline when the time spent exceeds a critical threshold of 15 h per week. Despite this fluctuation in EC, the depth and breadth of VK remain unaffected. While changes in academic time management can influence EC, they do not have a direct impact on VK. With the

rise or fall of EC levels, the overall VK of students remains stable. Academic time management can certainly help learners enhance their emotional state, such as reducing negative emotions (Tseng et al. 2006; Vohs and Schmeichel 2003). Nevertheless, it does not lead to a change in the level of VK.

In addition, a multi-group analysis demonstrated that the level of MES improves as academic time increases, which aligns with previous studies (Kramarski and Michalsky 2009). This suggests that as Vietnamese university students devote more weekly academic time to Chinese learning, their attention supervision in vocabulary learning becomes more positive. However, regardless of the increase in academic time, the VK level remains unchanged.

In general, while academic time management can influence SR, particularly in terms of MEC and EC, it does not significantly impact on the overall model. This suggests that allocating a reasonable amount of time to learning Chinese can help Vietnamese university students enhance their concentration and maintain positive emotion, which in turn supports stable Chinese vocabulary learning, especially in terms of vocabulary breadth. Given these findings, Chinese language teachers at Vietnamese universities should consider minimizing the number of vocabulary learning tasks assigned during class or as homework. Instead, they could use classroom time more effectively by incorporating engaging video materials, such as TikTok and YouTube clips, to explain the meanings of Chinese vocabulary and stimulate students' interest in learning language. Moreover, they can encourage students to use Chinese in real-life communication and interactions outside of class. This practice would help students deepen their understanding of vocabulary and improve their ability to use it effectively through oral expression and practical application.

Conclusion

This study found that Vietnamese university students' use of VLSs in learning CSL was positively influenced by their concentration and positive emotions. The students expanded their vocabulary by memorizing new words and practicing previously learned ones. However, this strategy was found to be independent of academic time management. Learning Chinese vocabulary, which is a time-consuming process, requires learners to maintain focus and manage stress to stay in an optimal state of vocabulary learning. While this approach helps to reduce negative learning moods and improve concentration, it did not contribute significantly to the depth of VK. As for academic achievement, given the importance students usually place on final exams, they tend to use VLSs and regulate their emotions during vocabulary learning with caution. This approach helps them achieve certain scores in breadth. This study filled a gap in research on SR in CSL vocabulary learning and further explored the relationship between VLSs and VK (breadth and depth), with SR as a mediating factor. Using Vietnamese students as an example, this study offers insights for future CSL vocabulary studies.

The findings of this study showed that CSL learners could expand their vocabulary size through self-regulatory strategies such as extending learning time and adjusting their attitudes towards vocabulary learning. However, the depth of VK might be more dependent on teachers' instruction. Therefore, teachers are encouraged to provide comprehensive instruction on Chinese vocabulary, including word identification, interpretation, and application. The study also found that the significance the university assigns to different exams influenced the students' learning strategies. The final exam had a significant moderating effect, while the midterm exam did not. To promote continuity in students' Chinese vocabulary learning and improve their VK, the

university should place equal emphasis on each exam, for example, by increasing the weight of the midterm exam in the final score.

This study explored the influence of SR on Chinese VLSs and employed SEM to identify moderating factors through cross-sectional research. Despite the valuable insights provided by this study, several limitations should be noted. Firstly, the underlying reasons why SR does not affect the depth of VK remain unclear and further investigation is needed to identify critical factors that may influence this process, such as gender. Additionally, the study's representativeness is limited to some extent, as the sample consists solely of university students from Vietnam. This limitation restricts the generalizability of the findings to Chinese learners in other regions with diversified cultural contexts and educational systems. Moreover, the sample's lack of variability in terms of size, regional distribution, and family income could introduce potential biases. The homogeneity of the sample may affect the results and limit the applicability of the conclusions to broader populations.

To improve and extend the current research, future studies should expand the sample size and include a more diverse range of participants in terms of region, gender, and socioeconomic background. Such diversity will improve the representativeness of the findings and allow for more comprehensive analyses. Furthermore, future studies should examine the role of factors such as gender, income, and region within the structural equation model. This approach will provide deeper insights into the relationships between vocabulary strategies, SR, and VK among Vietnamese Chinese learners.

Addressing these limitations and extending the scope of the research will be crucial for refining the existing findings and contributing to a more nuanced understanding of vocabulary learning processes.

Data availability

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

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Author contributions

Corresponding/First author is a dedicated scholar specializing in language studies. Her particular areas of interest include language contact and topologic linguistics, with a distinct emphasis on second language learning and language education. Second author excels in both qualitative and quantitative data analysis, with a special proficiency in SEM models. Third author investigates the mechanism of self-regulation and vocabulary learning strategies, and how they can be harnessed to enhance vocabulary knowledge.

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Competing interests

The authors declare no competing interests.

Ethical approval

The studies involving human participants were reviewed and approved by the Human Research Ethics Committee (Ref.no.2021-2022-0013) at The Education University of Hong Kong on October 28, 2021. The research was conducted in accordance with the ethical guidelines set forth by The Education University of Hong Kong. Additionally, all procedures involving human participants adhered to the ethical standards of the institutional and/or national research committee, as well as the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

Informed consent

Informed consent was obtained from all individual participants on June 5, 2021. All participants were provided with detailed written and verbal information about the purpose, scope, method, and possible risks of the study. They were assured that the information they provided would be kept confidential, their personal data would be protected, and the results of the research would only be reported anonymously. Participants were informed that they had the right to withdraw from the study at any time and were assured that their data would be destroyed in such case.

Additional information

Supplementary information The online version contains supplementary material available at <https://doi.org/10.1057/s41599-024-04322-5>.

Correspondence and requests for materials should be addressed to Cong Wang.

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